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Comparison of efficacy and recovery time of sevoflurane inhalation deep sedation with propofol deep sedation in pediatric dentistry

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ABSTRACT

The purpose of this study was to compare the efficacy and recovery time of inhalation sedation using sevoflurane to intravenous sedation using propofol. *Materials and Methods:* The study included 46 uncooperative children aged (3-6) year's who needed to undergo dental treatments under deep sedation. They were randomly assigned to two groups, the propofol group (Group P) and the sevoflurane group (Group S). All children were sedated by an anesthesiologist who was independent of dental treatment and was wholly responsible for the sedation procedure until the patient was discharged. The efficacy assessments and depth of sedation evaluation were done using the University of Michigan Sedation Scale (UMSS). After treatment, modified Vancouver Recovery Scale (MVRS) scale was used to determine the recovery time until the patient was discharged. *Results:* There were no significant differences in efficacy between groups. Statistically significant differences appeared in the recovery time between groups ($p = .000$). *Conclusions:* inhalation deep sedation with sevoflurane is an effective as propofol sedation in managing uncooperative children and the recovery of sevoflurane sedation was more quickly than propofol sedation.

Keywords: deep sedation, sevoflurane, propofol.

1. INTRODUCTION

Dental anxiety is one of the most frequently encountered problems in dentistry, which poses a real challenge to the dental team. Because of the excessive anxiety that a good proportion of children suffer from, they avoid not only dental treatment, but even dental examination, and because of this avoidance behavior of dental treatments, dental problems will worsen and thus become in need of more difficult and complex treatments, which will

ultimately increase the level of anxiety in the child (Hallonsten et al., 2013; McGrath and Bedi, 2004).

Sevoflurane was introduced to clinical practice in the early 1990s, although it was manufactured in the early 1970s (Wallin et al., 1975), partly because of the high costs of the equipment and attention to the toxic effects apparent at that time (Hitt et al., 1977), which over time turned out to be the result of a flawed experimental design (Ando et al., 2014). Nowadays sevoflurane, with its advantages, including the absence of harmful side effects on the various organs of the body, in addition to its pharmacokinetics and pharmacodynamics, has become universally accepted as a safe and reliable anesthetic agent for use in clinical practice (Ando et al., 2014).

Several characteristics such as pleasant odor, non-irritation of the airway and rapid recovery have made sevoflurane preferred for inhalation sedation in children and adults although sedation with sevoflurane has certain drawbacks. Some patients may find it difficult to tolerate the odor, which can cause nausea. It is necessary to maintain an airway due to excessive sedation. Since the anesthetic gas can diffuse into the treatment room, an adequate ventilation system is required (Kim and Kim, 2021). Studies have concluded that induction is as fast as or even faster than halothane (Baum et al., 1997; Sigston et al., 1997). Several studies have indicated the effectiveness of using sevoflurane as a substitute for nitrous oxide in the medical field such as: radiography, dentistry in conscious sedation procedures or deep sedation, especially in uncooperative young children (Mongodi et al., 2019; Lee et al., 2004; Kim et al., 2013; Lahoud et al., 2001; Sury et al., 2005).

Propofol has several properties that make it a popular drug for use for procedural sedation. Since it was introduced in 1977 as an inducing agent for general anesthesia, propofol has become commonly used in procedural sedation in the medical field. Its use has been studied by nonanesthesiologists and concluded that it is safe in the setting of bronchoscopy, cardioversion, percutaneous transluminal coronary angioplasty, endoscopy, and dental procedures (Dixon et al., 2019; Adinehmehr et al., 2019; Peng and Fang, 2020; Vargo et al., 2002; Canpolat et al., 2016).

Propofol is an excellent drug in young children when used in short procedures. It provides reliable sedation and immobilization while maintaining spontaneous ventilation (Svensson and Lindberg, 2012; Alzein et al., 2021; Scheiber et al., 1996; Seiler et al., 2001). We aimed in this study to investigate the efficacy and recovery time of two different sedation techniques, intravenous propofol, inhaled sevoflurane in children

2. MATERIALS AND METHODS

The study included a total of 46 children aged 3-6 years, were physically healthy (ASA1 "American Society of Anesthesiologists scale") required dental treatments under deep sedation due to negative or definitely negative behavior according to the Frankel Scale. The children were randomly assigned into 2 equal groups – group P and group S –. Exclusion criteria included children who are allergic to medications used in the study, severely impaired cardiorespiratory function.

Study duration was from August 2018 to September 2020. Approval of the ethical committee was obtained from related specific review board (the number of the ethical approval is 1363, dated March 2018). Written consent was taking from parents after providing a brief explanation of the procedures that will be taken, the desired benefits from them, and the participation of their child in the study. A comprehensive health evaluation of each child was performed by the sedation nurses, physician and the pediatric dentist. Medical questionnaires were filled out before the treatment procedure by the parents or guardians.

Fasting instructions were given to all children 6 hours before the treatment procedure (for solid foods and non-human milk), 4 hours (for human milk), and 2 hours (for water and clear liquids). Vital signs (including heart rate, blood pressure, respiratory rate, and oxygen saturation) were recorded before the treatment. In group S the child is placed in a supine position with the devices lying behind the child out of his field of vision. Sevoflurane evaporator was set by an anesthesiologist to give sevoflurane gas (Sevoflurane ®Piramal 250 ml) at (5-8%) and give 100% oxygen at (2-4) l / min using a face mask. After reaching the unconscious, the mask was replaced with a nasal cannula and sevoflurane gas was administered through the cannula. After local anesthesia, sevoflurane vaporizer was adjusted (1-4%) to achieve a deep sedation state until the end of the treatment. At the end of treatment, sevoflurane was stopped, and 100% oxygen gas was administered until the patient regains consciousness. Then patient was transferred to the recovery room and complications were recorded if they occurred.

In group P the child received a loading dose of intravenous propofol (Propofol-®Lipuro 10 mg/ml) of 0.5 mg/kg, then maintenance of deep sedation was achieved with Intermittent Bolus of 10 to 20 mg of propofol. The amount and timing of the bolus was at the judgment of sedating an anesthesiologist who existing throughout the sedation period until the end of treatment. Age, gender, weight, treatment time, recovery time was recorded. Vital signs (blood pressure - pulse rate - oxygen saturation - respiratory rate - electrocardiography) were recorded during dental treatment every 5 minutes until the end of treatment.

Efficacy assessment

The University of Michigan Sedation Scale (UMSS) (Malviya et al., 2002) was used to assess the depth and efficacy of sedation of each child during treatment was assessed by an external observer using recorded videos. The observer was trained in the use of the UMSS scale. Video tapes of pediatric dental patients treated under deep sedation were shown, and the differences between the different scores were explained to the observer by stopping the videotape and highlighting specific behavior corresponding to each score in accordance with each UMSS score.

Recovery assessment

Through two-minute intervals following the termination of dental treatment a modified Vancouver Recovery Scale (MVRS) was utilized to determine the length of time it took each subject to meet established discharge criteria. The discharge criteria were indicated in MVRS score of 1 (patient awake and oriented) or 2 (eyes open, responds to verbal questions) (table 1). Parents were contacted by phone one day after the operative visit to determine the occurrence of any complications during the past 24 hours.

Table 1 modified Vancouver Recovery Scale (MVRS)	
Score	Patient state
1	Fully awake and oriented
2	Eyes open, patient responds to verbal questions
3	Eyes open, does not respond to verbal questions
4	Eyes closed, patient does not respond to verbal questions
5	Eyes closed, patient arousable on mild stimulation
6	Eyes closed, patient not arousable on mild stimulation

Statistical Analysis

After data collection we used the statistical analysis software SPSS (Statistical Package for the Social Sciences, version 22, IBM, USA), we also used the Mann-Whitney test and Student's t-test to study the differences between the two groups. $p < 0.05$ was the criterion for statistical significance.

3. RESULTS

Patient characteristics in the two groups are shown in Table 2. The two groups were comparable for age, weight, and gender distribution. No significant differences were found among the two groups.

Table 2 Patient characteristics		
Variable	Propofol Group (n = 23)	Sevoflurane Group (n = 23)
Sex (male:female)	12:11	13:10
Age(years) (mean \pm SD)	4.5 \pm 1.3	4.3 \pm 1
Weight (kg) (mean \pm SD)	16.4 \pm 5.3	15.2 \pm 1.5

Recovery

Statistically significant differences were found between the groups in the duration of recovery time ($P = .000$) being longer in the propofol group than in the sevoflurane group (table 3, Figure 1).

Table 3 recovery time between groups			
Variable	Propofol group (n = 23)	Sevoflurane group (n = 23)	P value
Recovery time:			
Mean \pm SD	22.3 \pm 4.4	5.3 \pm 2.3	.000
Range	14-30	2-10	

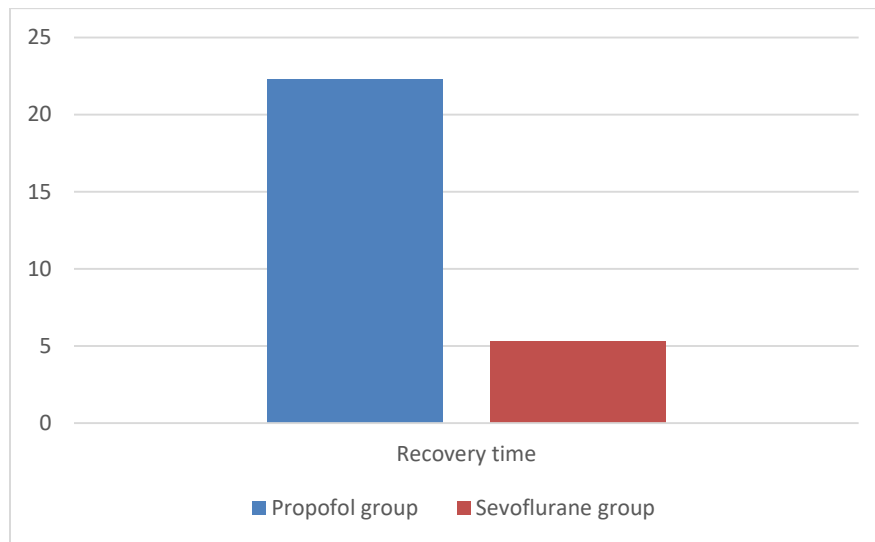


Figure 1 recovery time between groups

Efficacy

In the propofol group, the depth of sedation score according to UMSS was 3 (deeply sedated) in 19 children, 2 (moderately sedation) in 4 children. In the sevoflurane group, the depth of sedation score was 3 (deeply sedated) in 13 children, 2 (moderately sedation) in 10 children. There were not statistically significant differences between the groups in the efficacy according to UMSS ($P= 0.057$). No serious adverse events occurred during the treatment or in the recovery room. Also, no late complications were recorded by the children's parents in the 24 h following the operation in the two groups.

4. DISCUSSION

Procedural Sedation in dentistry provides an appropriate environment for providing excellent and comfortable treatment for children. Many studies have stated that intravenous and inhalation deep sedation is the safest and most effective sedation (Ozer et al., 2011; Badina et al., 2006; Kim et al., 2015). Sedation in children differs from sedation in adults. In adults, moderate sedation is often sufficient to complete dental treatment. In children, especially under the age of 7, deeper levels of sedation may be required to ensure control of their behavior and perform the treatment procedure in safety and quality. Whereas it can be difficult to control the behavior using moderate sedation, deep sedation and general anesthesia are required (Vetri et al., 2015; Singh et al., 2014). We should insure when choosing a sedative agent, a rapid recovery and adequate sedation level (Kim et al., 2013).

Propofol is an intravenous anesthetic agent that is characterized by rapid recovery even after prolonged injections. Propofol sedation is comparable to nitrous oxide-oxygen sedation in rapid recovery and without side effects. The recovery time when using propofol sedation in dental treatments is indicated as 11-22 minutes (Oei-Lim et al., 1991; Sakamoto et al., 1998; Oka et al., 2000). In uncooperative children, the use of inhalation sedation with nitrous oxide is inadequate. Sevoflurane inhalation sedation can be used as an alternative. The effectiveness of Sevoflurane is 55 times more than of N_2O : minimum alveolar concentration 2 vol % for sevoflurane versus 110 vol% for N_2O (Patel and Goa, 1996; Russell et al., 1990). There were no previous studies made in the field of pediatric dentistry to compare the efficacy and recovery time between propofol and sevoflurane. To our knowledge this study maybe considered the first of its kind.

In this study, the face mask used to sedate the patient replaced with nasal cannula instead of the nasal hood. Nasal hood can be an obstacle to performing dental treatments in pediatric patients, especially in the upper anterior region where nasal hood is placed, in order to overcome this issue; nasal cannula was used taking into consideration the use of an appropriate size cannula (Kim et al., 2013). The University of Michigan Sedation Scale was used to assess the depth and efficacy of sedation because it's a consistent tool that facilitates rapid and frequent assessment of depth of sedation in children in addition to its frequent use have been proven in several studies (Malviya et al., 2002).

Patients who have undergone sedation are monitored so that their recovery must be sufficient for a safe discharge home (Thomson et al., 1993). Many researchers indicated that the recovery time is the time between dental treatment completions until allowing the patient to safely discharge home, and therefore there are many different scales to assess the state of recovery in patients who have undergone sedation (Sakamoto et al., 1998; Oka et al., 2000). In this study Vancouver Recovery Scale was utilized to determine the length of recovery time. This study compared the recovery time since the end of dental treatment and until

meeting the discharge criteria when the patient achieves a score of 1 or 2 on the Vancouver scale. Patients sedated with sevoflurane met established discharge criteria more quickly than patients sedated with propofol. The mean recovery time in propofol group was (22.3 minutes) while it was (5.3 minutes) in sevoflurane group. There was significantly difference between two groups. The results of this study regarding recovery time indicated a success of sevoflurane versus propofol traditionally used for deep sedation. This result is consistent with previous studies that reported speed recovery time when sevoflurane is used to sedated pediatric dental patients (Lee et al., 2004; Kim et al., 2013; Kim et al., 2015). Through this study, no statistically significant differences were found between the propofol and sevoflurane groups with regard to efficacy. This is consistent with the researchers' indications of the effectiveness of sevoflurane in managing uncooperative children who need dental therapies.

5. CONCLUSION

Deep sedation "provided by an anesthesiologist who is responsible for administration drugs and to continuously monitor the patient's vital signs, airway patency, cardiovascular and neurological status, and adequacy of ventilation isn't involved in the dental procedure" with propofol, or sevoflurane is an effective in treating uncooperative children. Sevoflurane inhalation sedation provides a rapid recovery time more than when using intravenous propofol sedation.

Author Contributions

Mhd Raslan Alzein: conceptualization, methodology, investigation, data curation; Mohamed Altinawi, Faten Rostom: conceptualization, methodology, investigation, supervision; Imad Katbeh: writing - original draft, writing – review & editing; Mamasaidova Zarina, Saidova Patimat: writing-review & editing.

Ethical approval for study protocol

The study was approved by the Medical Ethics Committee of Damascus University (ethical approval number 1363, dated March 2018).

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Conflict of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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